The design of voice controlled assistive technology for people with physical disabilities

Mathijs Verstraete[1], Jan Derboven[1], Jort Gemmeke[2], Peter Karsmakers[3], Bert Van Den Broeck[3], Hugo Van hamme[2]

[1]Centre for User Experience Research (CUO), IBBT-KU Leuven Future Health Department, Parkstraat 45 Bus 3605, 3000 Leuven, Belgium
{mathijs.verstraete, jan.derboven}@soc.kuleuven.be
[2]KU Leuven – Dept. ESAT, Kasteelpark Arenberg 10, 3001 Leuven, Belgium
{jort.gemmeke,hugo.vanhamme}@esat.kuleuven.be
[3]Mobilab, KH Kempen (association KU Leuven), Kleinhoefstraat 4, 2440, Geel, Belgium
{peter.karsmakers, bert.van.den.broeck}@khk.be

Abstract. The ALADIN project aims to develop an assistive voice control system for people with physical disabilities. This position paper describes the user-centered design approach used in the project to identify the users needs, and to design the interaction with the assistive technology.

Keywords: Assistive technology, voice interface, user interaction, HCI

1 Introduction

Voice control of the technology that we use in our daily lives is perceived as a luxury, suited only for situations in which hands-free control is appropriate, such as in-car voice control systems. Apart from these specific hands-free situations, more common interactions and input methods are often considered more suitable. A remote control, for instance, can be better suited for home automation because often, it is easier to push a button than to say a command.

However, for people with a physical impairment, pushing a button is not always as easy as it is for most people. For this target group, a wide range of assistive technologies is currently available, including traditional joysticks, touchless finger joysticks, tablets, chin switches, pedals, head-mounted switches, etc. Nevertheless, only a restricted amount of information can be transmitted through these devices. Also the speed of operation and the complexity of the function one wants to accomplish are important boundaries. In addition, the physical effort in using these devices is a burden for some users (see Fig.1).



Fig. 1. Remote controls used by people with a physical impairment.

To increase speed and complexity on the one hand, and reduce effort on the other, voice interaction can be a viable solution. What is perceived as a luxury for most people can actually mean a significant improvement in the quality of life for a disabled person. Furthermore, it has a high social impact for this target group.

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2 Obstacles in Voice-Controlled Assistive Technology

Even though voice interfaces can provide significant improvements for specific target groups, they are currently not widely used for assistive devices for several reasons. Technology for people with disabilities often needs to cope with a high level of variation in user requirements for assistive technology, creating high individual adaptation and development costs. In addition, users for whom voice commands could be of added value, often also have a speech pathology, such that state-of-the-art speech recognizers are unusable for them. Moreover, the user's voice may change over time due to progressive speech impairments.

The ALADIN project proposes an approach that is based on learning and adaptation. The interface should learn what the user means with his/her commands, which words he/she uses and what his/her vocal characteristics are. Users should be able to formulate commands they like, using the words they like and only addressing the functions they are interested in. Learning takes place by using the device, i.e. by mining the vocal commands and the change they provoke to the device. This approach has not been taken by any other commercial available voice system.

3 User-Centered Design Methodology

3.1 General

With regard to interaction design, voice user interfaces (VUIs) are often considered a 'non-traditional' interface. Most interaction design (and subsequently most design methods) is focused on interfaces with a heavy focus on visual information and manual user input, such as software interfaces, websites, physical products, etc. However, in the last decade, more and more research has been carried out into the design of usable VUI's, which has resulted in general guidelines for designing VUI's [1]. Most of this research and design principles are aimed at VUIs for mainstream applications. Research into VUIs for users with disabilities is still scarce.

Both VUI design, as a non-standard interface, and designing for users with disabilities require a thorough Human-Centred Design (or User-Centred Design (UCD)) approach [2,3]. In a human-centered design approach, the end-users are the central focus in the design of new products or applications. This is especially important when the end-users are very different from the designers and developers who might have difficulties empathizing the actual end-users. The problems, needs, tasks and contexts of the end-users are addressed during each phase of the design and development process and end-users are actively involved throughout the entire process. This way, the match between the products or applications under development on the one hand and the user needs on the other hand can be optimized from an early stage onwards. Continuously keeping an eye on the user needs allows for high levels of usability and a positive user experience. In addition, later changes to meet user needs and future redesigns to enhance usability are reduced.

3.2 User and task analysis

In the first phase of the project, we gathered background information of the participants, their pathology, limitations, caregivers and tasks, leisure time, time consumption and living environment. The group of participants ranged within different parameters, grade of independence and limitation. In addition to the interviews, every participant was asked to guide us through their home while telling about and performing their daily tasks, e.g. explaining the tools they use, difficulties they encounter, etc. By doing this we gained a good insight of the abilities and needs of the user.

3.3 Scenario Test Sessions

As the ALADIN system is based on learning what the users mean with a specific voice command, it is important to get a clear view of the variability of the voice related acoustical parameters and type of commands they choose. To get an understanding of how people address voice-controlled technology, test sessions were held with scenario visualizations.



Fig. 2. Scenario visualization.

The scenarios (example in Fig. 2) were presented to the respondents, starting from simple situations to more complex ones. Guided by the scenarios, the moderator asked the respondents to formulate any voice command they wanted, without worrying about any system limitations. The scenario visualizations were used in order to avoid biasing respondents with specific words or sentence structures. In the process, the sketches were completed with additional elements (see Fig. 3), adapting the scenes to the participants emerging system image. For later analysis, the entire process was videotaped.

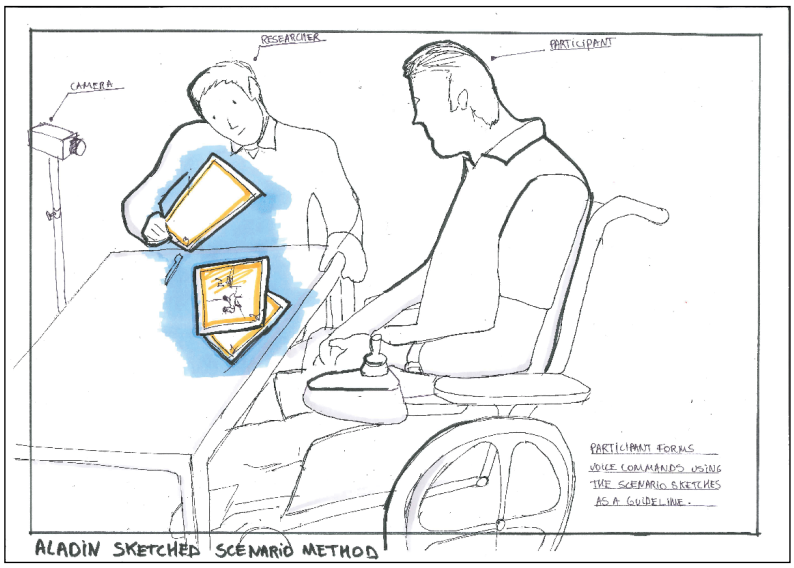


Fig. 3. Sketched scenario method.

The above test sessions provided significant material on how test users address a voice interaction system. Significant variation was found, for instance ranging from a purely 'technical', command-style interaction to a more anthropomorphized, personal communication with the system. This last group tended to make a conversation with the system in a human or natural way, while the command style interaction implies a way of thinking in terms of efficiency and reliability, which is very important for this specific target group. Likewise we distinguished different ways of how people want to communicate and interact with a voice-controlled system. We observed various ways of how people formulate commands; activating and stopping the system, specifying and altering commands. In addition, some respondents addressed individual devices, without addressing the voice-control system separately, while other respondents addressed the voice-controlled system as a whole, telling it to act on the environment and control other devices. For this last group, addressing separate objects such as doors felt very unnatural. On the other hand, the device-oriented way of thinking implies a different technology approach, in which the system can identify the users' intentions based on their location and context (for instance, 'light on' turns on the lights in the room where the user is, without specifying which particular lamp).

4 Functionalities

Based on the user and task analysis we gained insight in the target group and how they organize their everyday life and routines, their tasks and their contexts. Depending on these users' needs and abilities

we will develop different functionalities; home automation, communication tools and entertainment functionalities. For people with limb impairments, successful voice control can have significant impact on the quality of life by facilitating independent living and communication. A voice-controlled environment can contribute to independence of living: being able to perform actions autonomously gives a sense of freedom, increases self-esteem and gives a feeling of regaining power over the environment. For example: Opening a door by your own command instead of asking someone to open a door. Apart from independent living, the system can also extend communicative abilities. A typical application of this technology would be the control over a telephone, which may not be within reach of the user. Relatedly, new ways of calling for help in emergency situations are opened by facilitating communication. In addition to addressing basic needs such as independent living and communication, a voice-controlled system can also provide new opportunities for entertainment. Being able to operate recreational devices such as the television and radio are straightforward – but important – examples. Other avenues that can be explored include gaming, playing chess or solving Sudoku puzzles.

5 Conclusion and Future Work

The ALADIN project aims to develop an assistive voice control system for people with physical disabilities, as voice interfaces can provide significant improvements for this specific target groups. So far, we got insight of how people with a physical impairment differ in communicating with assistive voice systems. In addition to the conventional user and task analysis, we used the sketched scenario method to get an understanding in how people would interact and communicate with such systems without biasing the participants. Future work in the project includes the actual design of the voice user interface, incorporating feedback and correction mechanisms, learning patterns, etc.

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References

1. Cohen, M. H.,Giangola, J. P., & Balogh, J.: Voice user interface design. Addison-Wesley Professional, (2004)
2. Mayhew, D. J.: The Usability Engineering Lifecycle: A Practitioner's Handbook for User Interface Design. Morgan Kaufmann, (1999)
3. Sharp, H., Rogers, Y., & Preece, J.: Interaction design: beyond human-computer interaction. Wiley, (2007)